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US 5129496 A

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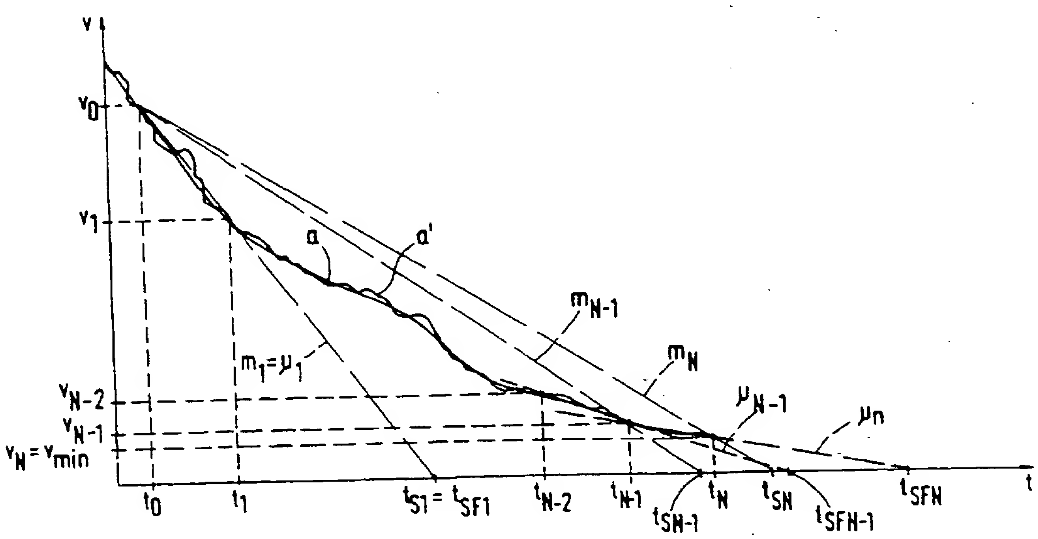
(54) **Method of predicting vehicle standstill**

(57) A method of determining a time when a vehicle becomes stationary comprises the steps of determining a threshold speed value (v_0) for at least one wheel during a braking phase, detecting at least one further speed value (v_1 ... v_{N-2}, v_{N-1}, v_N) for the wheel or wheels at a plurality of successive times (t_1 ... t_{N-2}, t_{N-1}, t_N) to the attainment of a measurable minimum speed, and estimating the time point (t_{SN} or t_{SFN}) for the stationary state of the vehicle by forming one or more speed gradients (m_1 .. m_{N-1}, m_N) between the speed values and by extrapolating them to the zero speed.



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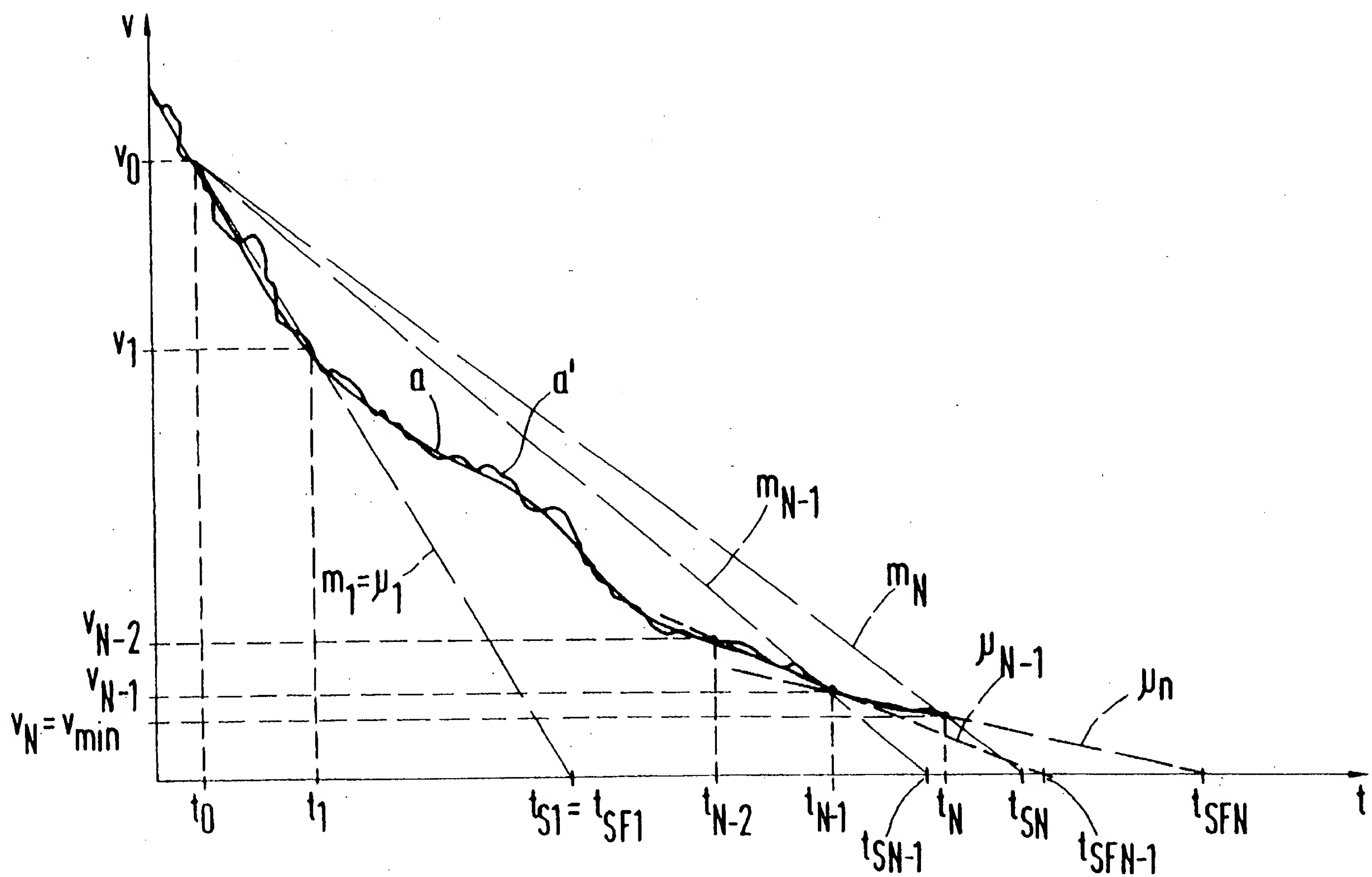
v
v_0
v_1
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$v_N = v_{min}$
a
a'
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μ_{N-1}
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t_0
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METHOD OF PREDICTING VEHICLE STANDSTILL

The present invention relates to a method of determining a time point when a vehicle becomes stationary.

It is necessary to determine the time point when a vehicle becomes stationary for cases where information on this time point is to be further evaluated. For example, information on the stationary state of the vehicle is required for use in implementation of an anti-roll function. After the vehicle has attained a stationary state, an anti-roll device serves to apply a parking brake, without further interventation of the driver, until the vehicle is started again. For reasons of safety and driving comfort, a build up of braking pressure at wheels at which braking is to be applied should not take place until the vehicle is stationary. The smallest, reliably measurable wheel speed is the threshold speed, so that the time when the vehicle becomes stationary cannot be measured precisely.

When controlling an internal combustion engine it is known, according to EP 0 490 088 A2, to identify crankshaft angle position by means of an absolute value angle sensor which comprises a wheel which is mounted on the crankshaft and bears on its surface a code which is scanned by a sensor. The electrical signals acquired during this process are fed to an engine stationary-state detection circuit, in an input stage of which the input signal is electronically differentiated and fed to a counter, which in the absence of an input signal, generates an output signal corresponding to the engine state. Such a procedure could not provide an exact result for the actual

time when the vehicle itself becomes stationary.

There is therefore a need for a method for determining a time point when a vehicle becomes stationary, which method may allow for the requirements of safety and driving comfort and requires only minimal outlay.

According to a first aspect of the present invention there is provided a method of determining a time point when a vehicle becomes stationary, comprising the steps of determining a threshold speed value for at least one wheel of the vehicle during a braking phase, subsequently detecting at least one further speed value for the at least one wheel at a plurality of successive time points until attainment of a measurable minimum speed, and estimating the time point for the stationary state of the vehicle by forming at least one speed gradient between such speed values and by extrapolation thereof to the zero speed.

According to a second aspect of the invention there is provided a method of operating a vehicle with an anti-roll control, comprising the steps of performing the method according to the first aspect of the invention and causing the parking brake of the vehicle to be automatically applied at the estimated time point and maintained until the vehicle is restarted.

It is therefore provided that a threshold speed value is determined for at least one wheel during a braking phase, that, subsequently, at least one further speed value for the wheel or wheels is identified at a plurality of successive times until a measurable minimum speed is reached, and that the time for the stationary state of the vehicle is estimated by forming one or more

speed gradients between the identified speed values and by extrapolating them to the zero speed. By forming the speed gradient or gradients between the identified speed values and by extrapolating them to the zero speed, a time for when the vehicle becomes stationary is obtained; this time satisfactorily represents the actual time - which cannot be measured precisely - when the vehicle becomes stationary. If this time is used for, for example, the time of application of a vehicle parking brake, jerky braking is avoided and the parking brake is applied sufficiently quickly.

The accuracy of the estimated value of the time when the vehicle becomes stationary can be improved by extrapolating the average speed gradient between the threshold speed value and the last speed value identified and/or by extrapolating the instantaneous speed gradient between the next-to-last speed value identified and the last speed value identified.

The result of the estimation of the time when the vehicle becomes stationary becomes even more reliable if there is provision that at least the last two instantaneous speed gradients are compared with the two corresponding average speed gradients and, if these two instantaneous speed gradients either exceed or drop below the corresponding average speed gradients by a fixed minimum amount, the instantaneous speed gradient or, otherwise, the average speed gradient is used to estimate the time. Preferably, the average speed gradients and the instantaneous speed gradients are identified at at least three wheels of the vehicle and the maximum of the estimated stationary-state times of the wheels is selected as the estimated time when the vehicle becomes stationary.

The estimated result can be optimised by using the instantaneous speed values instead of the average speed values when the at least last two instantaneous speed gradients exceed or drop below the corresponding average speed gradients by the fixed minimum amount at at least three wheels.

By virtue of these measures, random influences which may affect the estimated value are virtually completely eliminated.

The method is advantageously used in a motor vehicle with an anti-roll function, the parking brake of the vehicle being automatically applied at the estimated time and maintained until the vehicle is restarted. Safety and driving comfort during braking are ensured in that early, jerky activation of the parking brake system is ruled out, but the process of applying the parking brake does not take place too late.

Preferably, a control unit of an anti-lock brake system/traction control system is triggered at the estimated time and the vehicle driving wheels have the necessary braking pressure applied to them via valves of the system, the anti-roll function preferably being triggered by the driver activating the brake and when the engine is disengaged or idling. By virtue of these measures, the method of predicting vehicle standstill is integrated to an optimum degree into an anti-lock brake system/traction control system in order to implement the anti-roll function.

Examples of present invention will now be more particularly described with reference to the accompanying drawing, the single figure of which is a diagram showing the speed profile v of a wheel, plotted against time t and a number of average speed gradients and

instantaneous speed gradients.

Referring now to the drawing, there are shown speed gradients which are formed by detecting speed values v_0, v_1 ... v_{N-2}, v_{N-1}, $v_N = v_{min}$ for a wheel speed curve a at measurement times t_0, t_1 ... t_{N-2}, t_{N-1} and t_N, wherein v_0 is a threshold value and v_{min} is last measurable wheel speed. The curve a can be obtained from, for example, an actual speed curve a' by smoothing, using a suitable filter method if the actual speed curve a' is not sufficiently smooth for identifying the speed gradients.

The formation of speed gradients is initiated as soon as the speed of a wheel drops below a defined threshold speed value. For each wheel the average speed gradients m_1 ... m_{N-1} and m_N between the defined threshold value v_0 and the actual speed value v_1 ... v_{N-1} and v_N are determined and extrapolated as far as the zero speed in order to obtain a first reference value for a time t_{S1} ... t_{SN-1} and t_{SN} when the vehicle becomes stationary. This reference value is updated for each wheel up to the last measurable wheel speed. On failure of a rotational speed sensor to provide a speed signal, the last detected time t_{SN} serves as a provisional time for when the associated wheel becomes stationary. On failure of the last sensor signal, the maximum of the calculated stationary-state times for the wheels is used as an estimated value for the expected time when the vehicle becomes stationary.

A "fine estimation", which allows for change in the speed gradient and is based on the formation of an instantaneous speed gradient μ_1 ... μ_{N-1}, μ_N, runs in parallel with this procedure. This procedure also starts at the time t_0 when the speed drops below

the threshold speed value v_0. In contrast with the procedure described above, the reference speed and reference time for the formation of gradients do not remain constant but are always replaced by the actual wheel speed and associated times after a time period, which is to be fixed, has expired. Otherwise, the described procedure is maintained for the calculation of the new stationary-state times t_{SF1} ... t_{SFN-1} and t_{SFN}. Instead of the average speed gradient, this procedure supplies the instantaneous speed gradient in approximated form.

If the n last instantaneous speed gradients μ_N, μ_{N-1} at at least three wheels either drop below or exceed the average speed gradients m_N, m_{N-1} by a fixed minimum amount, the instantaneous speed gradients are used instead of the average speed gradients for estimating the time t_{SFN}. Otherwise, the average speed gradients are utilised to estimate the time t_{SN} when the vehicle becomes stationary.

The described gradient method permits the time when the vehicle becomes stationary, which cannot be detected by technical measuring means, to be predicted.

The estimated time t_{SN} or t_{SFN} when the vehicle becomes stationary can be used as a basis for automatic signal issue or control. An important application is, for example, the implementation of an anti-roll function for motor vehicles, which function is monitored and triggered by means of a control unit for an anti-lock brake system/traction control system. After the vehicle has been braked to a stationary state, an anti-roll device serves to apply a parking brake, without the intervention of the driver, and maintained until the vehicle is started again. For this purpose, the

driving wheels of the vehicle have the necessary braking pressure applied to them via the valves of the traction control or anti-lock brake system. At the same time, for reasons of safety and driving comfort, the build up of pressure should not take place until the vehicle is stationary, for which the estimated time when the vehicle becomes stationary, identified according to the method described above, is advantageous.

CLAIMS

1. A method of determining a time point when a vehicle becomes stationary, comprising the steps of determining a threshold speed value for at least one wheel of the vehicle during a braking phase, subsequently detecting at least one further speed value for the at least one wheel at a plurality of successive time points until attainment of a measurable minimum speed, and estimating the time point for the stationary state of the vehicle by forming at least one speed gradient between such speed values and by extrapolation thereof to the zero speed.

2. A method as claimed in claim 1, wherein the step of estimating comprises extrapolating the average speed gradient between the threshold speed value and the last detected speed value and/or extrapolating the instantaneous speed gradient between the penultimate and the last detected speed values.

3. A method as claimed in claim 1 or 2, wherein at least the last two instantaneous speed gradients are compared with the two corresponding average speed gradients and if said two instantaneous speed gradientss exceed or fall below the corresponding average speed gradients by a fixed minimum amount the instantaneous speed gradient and, otherwise, the average speed gradient is used to estimate the time point for the stationary state.

4. A method as claimed in claim 2 or claim 3, wherein the average

speed gradients and the instantaneous speed gradients are formed from speed values detected at at least three wheels of the vehicle and the maximum of the stationary-state time points estimated from the values applicable to the individual wheels is selected as the estimated value for the expected time point when the vehicle becomes stationary.

5. A method as claimed in claim 3 when appended to claim 4, wherein the instantaneous speed values are used instead of the average speed values when said two instantaneous speed gradients exceed or fall below the corresponding average speed gradients by the fixed minimum amount at said at least three wheels.

6. A method as claimed in claim 2 and substantially as hereinbefore described with reference to the accompanying drawing.

7. A method of operating a vehicle with an anti-roll control, comprising the steps of performing the method as claimed in any one of the preceding claims and causing the parking brake of the vehicle to be automatically applied at the estimated time point and maintained until the vehicle is restarted.

8. Method as claimed in claim 7, wherein a control unit of an anti-lock brake system/traction control system of the vehicle is triggered at the estimated time point and a braking pressure is applied to the driving wheels of the vehicle by way of valves of the system.

9. Method as claimed in claim 7 or claim 8, wherein the anti-roll function is triggered by the vehicle driver actuating the vehicle brake and when the vehicle engine is disengaged from the vehicle driving wheels or idling.

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Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

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GB 9601610.0

Relevant Technical Fields

(i) UK Cl (Ed.O) G1K

(ii) Int Cl (Ed.6) G01P 13/00

Search Examiner
A BURROWS

Date of completion of Search
27 MARCH 1996

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE: WPI

Documents considered relevant following a search in respect of Claims :-
1-9

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
X	US 5129496 (BOSCH) lines 17-26 column 4	1

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